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CMS NOTE 2001/***

The Compact Muon Solenoid Experiment

CMS Note

Mailing address: CMS CERN, CH-1211 GENEVA 23, Switzerland

19th, Oct, 2001

Dijet mass resolution with or without the Endcap Ecal at CMS

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Abstract

This note shows that the dijet mass resolution has no significant changes for the CMS calorimeter with or without the Endcap Ecal. The results from the cms120 and test run in PC by the full ORCA[1] production are essentially the same.

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1 Introduction

Zp-jet mass resolution is the most simple physics process to exam the performance of the CMS calorimeter. We have studied this topic using parameterized simulation program with High luminosity for CMS hadron calorimeter [2], later we have used GEANT based full simulation program to study the dijet mass resolution again in detail [3]. Two years ago, a question needed a quick answer: if due to budget reason, we will run CMS experiment without the Endcap Ecal at the first stage, how much will degrade our potential capability for discovering the Higgs in the decay model of Higgs into 2 gammas? We have used parameterized simulation package to give a quick answer to the question[4]. Today, it seems that we will indeed to run the CMS experiment without the Endcap Ecal at the early stage. We want to know what is a impact to the Zp dijet mass resolution in general. Now, the full detector simulation program is avaliable, specially the geometry is much closer ever to the reality. Also, the ORCA (Object Reconstruction for Cms Analysis) program[1], contains hits and digitization, is avaliable. To test the ORCA also motivated us to make this study again.

2 Simulation and analysis tools

The calorimeter was simulated using GEANT3 within the framework of the CMS general simulation program CMSIM(version 120). The electromagnetic calorimeter (ECAL) consisted of 23 cm PBWO4 crystals followed by the support structure. The barrel part covers up to η 1.8, the Endcap Ecal supposed to cover between η 1.8 to η 2.3. Without the Endcap Ecal means that the space has been left empty as a air in the detector, which is setup as well as in our GEANT simulation for the study in case of without the Endcap Ecal. The hadron calorimeter(HCAL) consisted of layer of copper absorber, 5.0 cm thick (7.9 cm in the endcap), separated by air gaps containing the scintillator package. The thickness of the calorimeter inside the solenoid was 6.9 $lamda$ at η=0. The detail of detector design can be found in HCAL Technical Design Report(TDR)[5]. First, we were using CMGEN to generate Zp dijet events, with Zp mass equals 120 GeV/c, and then using CMSIN120 to simulate the events, and create the ntpl file to be analyzed and the fz file for later use to be input into the ORCA. We used our simple cone algorithm to make jet finding, then used the two highest Et jets to reconstruct the dijet mass using cone size of 0.5. We also used all final stable particle to reconstruct the jets, which is supposed to be the reconstructed jet without detector effect, as generated level jets. Then we also reconstruct the dijet mass from these jets. The final resolution is obtained from the ratio of the reconstructed dijet mass over the generated dijet mass, so the error in the generated level were canceled. The Et threshold to be used for jet finding is 20 GeV. Second, we were using the output .fz file from the CMSIM120, to input to ORCA program package. The ORCA reads cmsim fz file and writes cmsim hits to the database. Pileup can be added to the data sample. For this study, we did not add any pileup in the analysis. Full digitization have been done. Then we further to execute the JetMet analysis package, which is part of ORCA to produce the new ORCA standard ntpl file. The new ORCA standard ntpl file contains all generated and reconstructed jets and $\not\!\!E_T$ information. On base of this new ntpl file, we reconstruct the Zp dijet mass, and make the same plot as we had in the first step using original ntpl file.

3 Data sample

We generate four data samples.

a) Zp dijet with full detector, and without initial and final statue radiation.

b) Same with above, but with GEANT parameter loss=2, namely no Δ -ray production in the program.

c) Zp dijet without the Endcap Ecal, and without initial and final statue radiation.

d) Zp dijet with full detector, but with initial and final statue radiation.

Compare case a) and b), it will give a idea how Δ-ray production could effect the dijet mass resolution(Gaussian part), and how to effect to the tail part.

Compare case b) and c), it will give a idea how the Endcap Ecal will effect to the dijet mass resolution, as well as how to effect to the tail part.

Compare case a) and d), it will give a idea how radiation will effect the mass resolution and the tail.

We did not make special calibration adjustment, namely using same calibration factor for all cases, in order to see what is the worst cases which is shown in our Note.

4 Results from the cmsim

The summery results are listed in the table 1.

Value	A	B	C	D	E
Full detector %	14.2	12.7	12.0	15.6	13.5
Full detector No Δ-ray %	14.5	13.4	11.4	15.9	15.8
No Endcap Ecal %	13.8	12.3	11.2	15.2	13.4
Full detector with I/F radiation %	24.9	21.7	21.8	—	—

Table 1: Summery results of Zp dijet mass resolution study

Value A : Dijet mass resolution with all η region
Value B : Dijet mass resolution with at least one jet in the Endcap region
Value C : Dijet mass resolution with both jets are in barrel region
Value D : Ratio of E_T generated over reconstructed with all η region
Value E : Ratio of E_T generated over reconstructed with at least one jet in the Endcap region

One can see that there is no significant differences in term of the dijet mass resolution for case a), b) and c), only the initial and final statues radiation will degraded the mass resolution. This conclusion is agreed with previous study[4], which indicated that only the Higgs acceptances is reduced but not much effect to the mass resolution if CMS run without the Endcap Ecal. In the following figures, we always put case a) in the top-left, case b) in the top-right. The case c) in the down-left, case d) in the down-right.

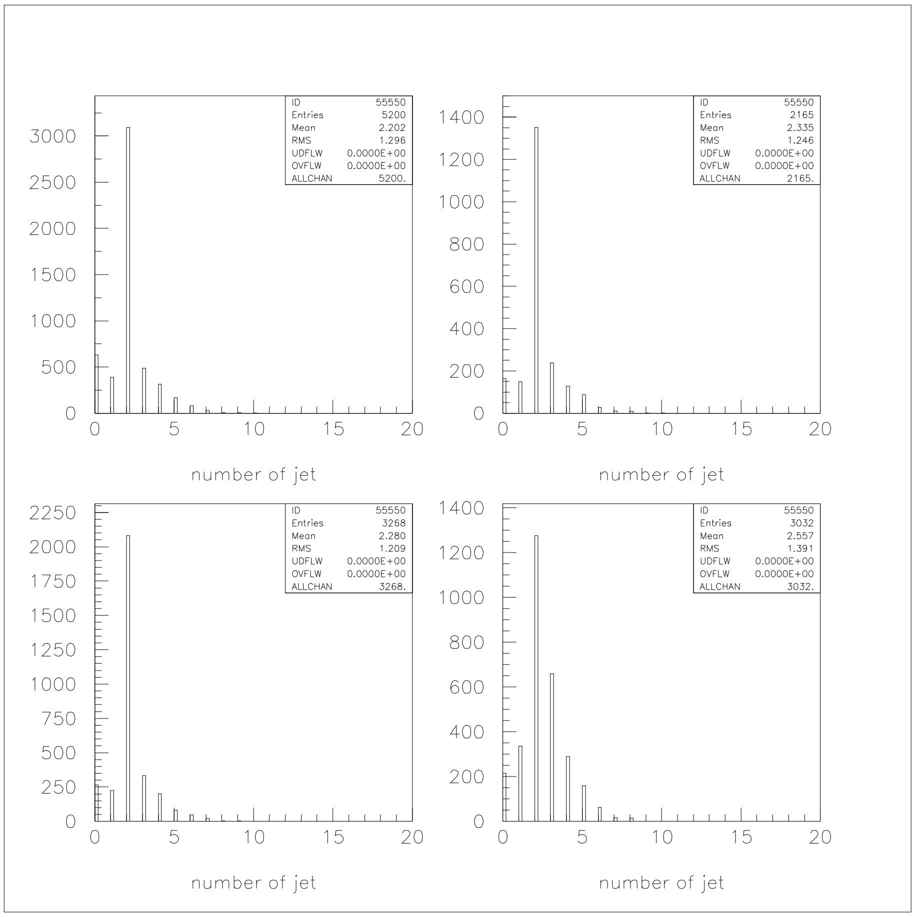

Figure 1: Jet multiplicity: (a) full detector, (b) full detector, no Δ-ray production (c)without the Endcap Ecal (d) full detector with I/F radiation

Fig. 1 shows the number of jets found in the events. As expected, the most of case, the number of jets should be two. However, there are about 20 events are not two jets. We can adjust the jets threshold or cone size to get slightly different figure, but basically the jet multiplicity is as shown. Even with ORCA, which used complected algorithm to find the jets, but the situation is the same which we will mentioned later. Moreover, when we reconstruct the dijet, it is not always true that the events in which the Zp have the highest Et, has only two jets in the events. Namely, there is additional jets which not from the Zp in some events. The situation gets worse if events were generated with I/F radiation. In our analysis, we only proceed the events which has more or equal than two jets.

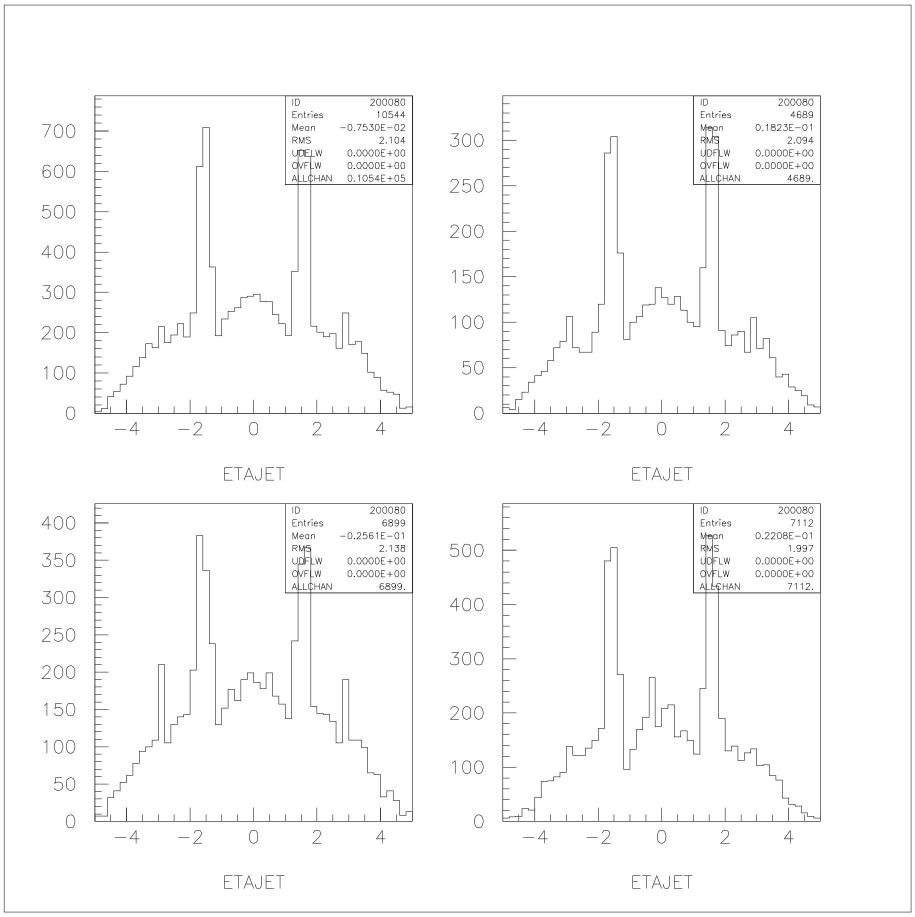

Figure 2: Jet η distribution: (a) full detector, (b) full detector, no Δ-ray production (c)without the Endcap Ecal (d) full detector with I/F radiation

Fig. 2 shows the η distribution of all jets. One can see that the dijet mostly are located in η region between 1 to 2. That probably is the reason why we found the jet E_T correct routine, doesn't make improvement for the data sample without I/F radiation, since the data set inside of the jet E_T correct routine are based on widely η distributed QCD jets. Small bump around η 2.5 reflects the border of the Endcap and forward calorimeter in which the cell size has discontinued changes, this is specially true for case c) if there is no Endcap Ecal.

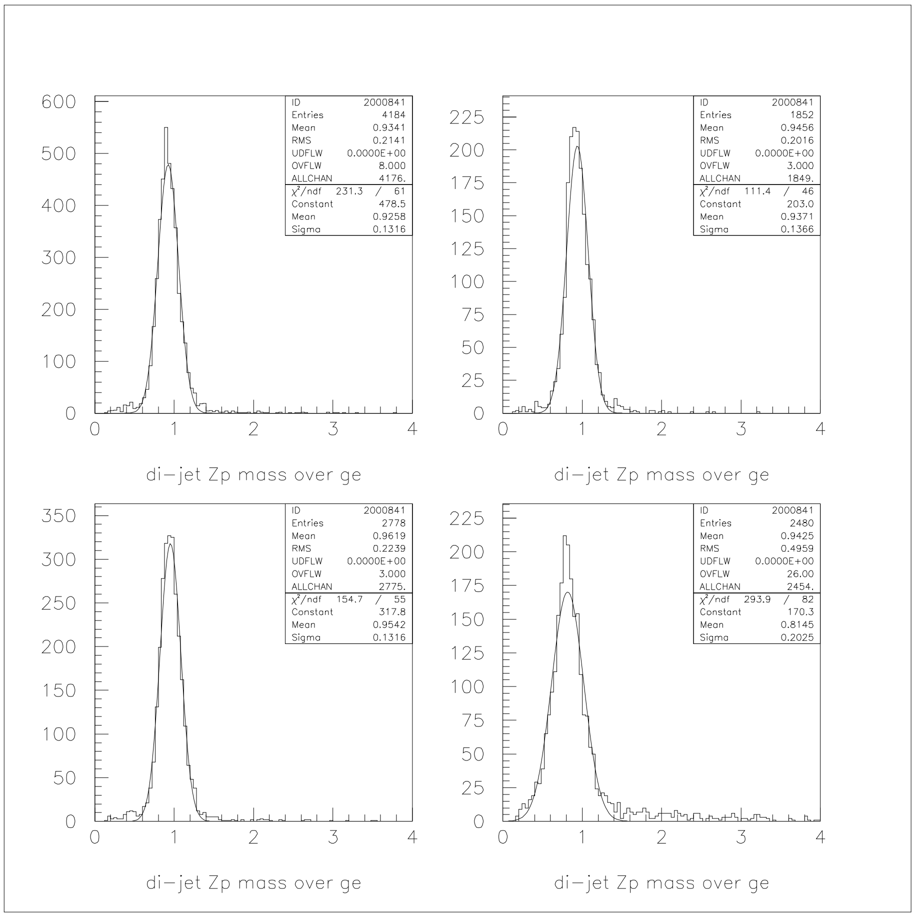

Figure 3: Dijet mass resolution: (a) full detector, (b) full detector, no Δ-ray production (c)without the Endcap Ecal (d) full detector with I/F radiation

Fig. 3 shows the ratio of reconstructed Zp mass over generated level Zp mass. One can see that there is no significant differences for case a), b) and c) in term of mass resolution. Only the initial and final radiation will degrade the mass resolution significantly.

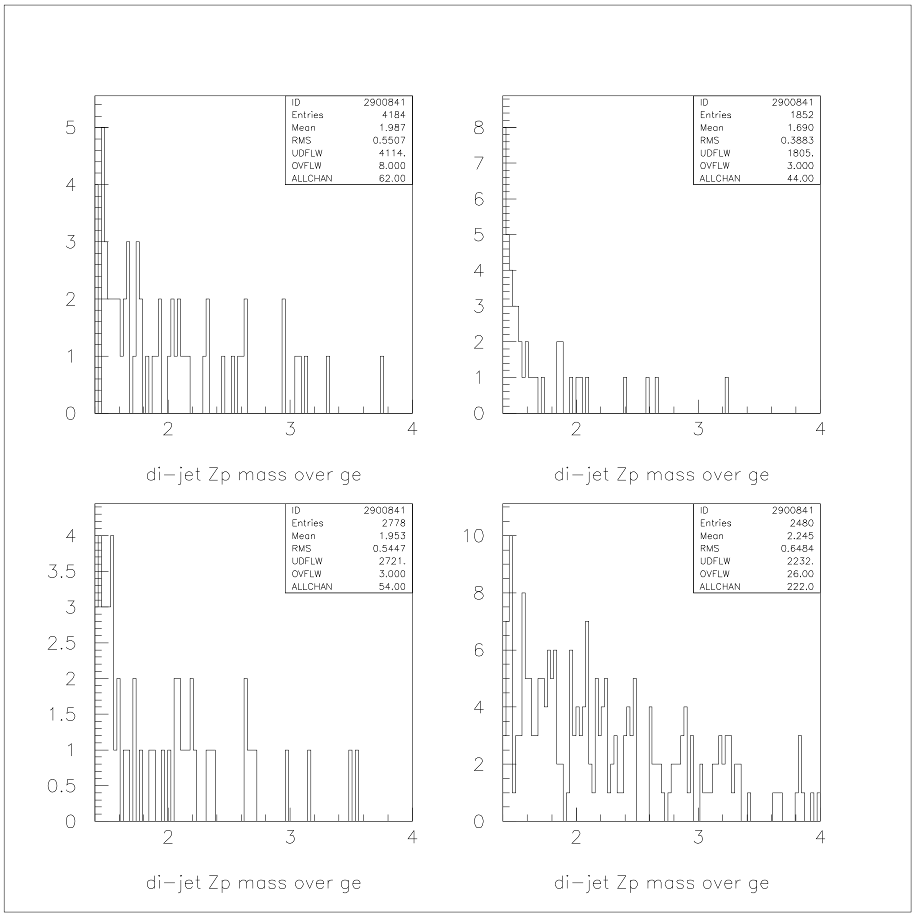

Figure 3.1: Dijet mass resolution, the tail part: (a) full detector, (b) full detector, no Δ-ray production (c)without the Endcap Ecal (d) full detector with I/F radiation

However, if we look at the Fig.3.1, which is the tail part of Fig.3, one can see that if without Δ-ray, it will have less events in the tail, and if without the Endcap Ecal, it will cause more events in the tail. The percentage of the events in tail from the total events for case a), b), c), d) are :1.7 %, 2.5 %, 2.0 % and 10.0 %. It is what we have expected. Dominate factor are the initial and final statues radiation, so without the Endcap Ecal even the possible wrong trigger rate will not be increased too much.

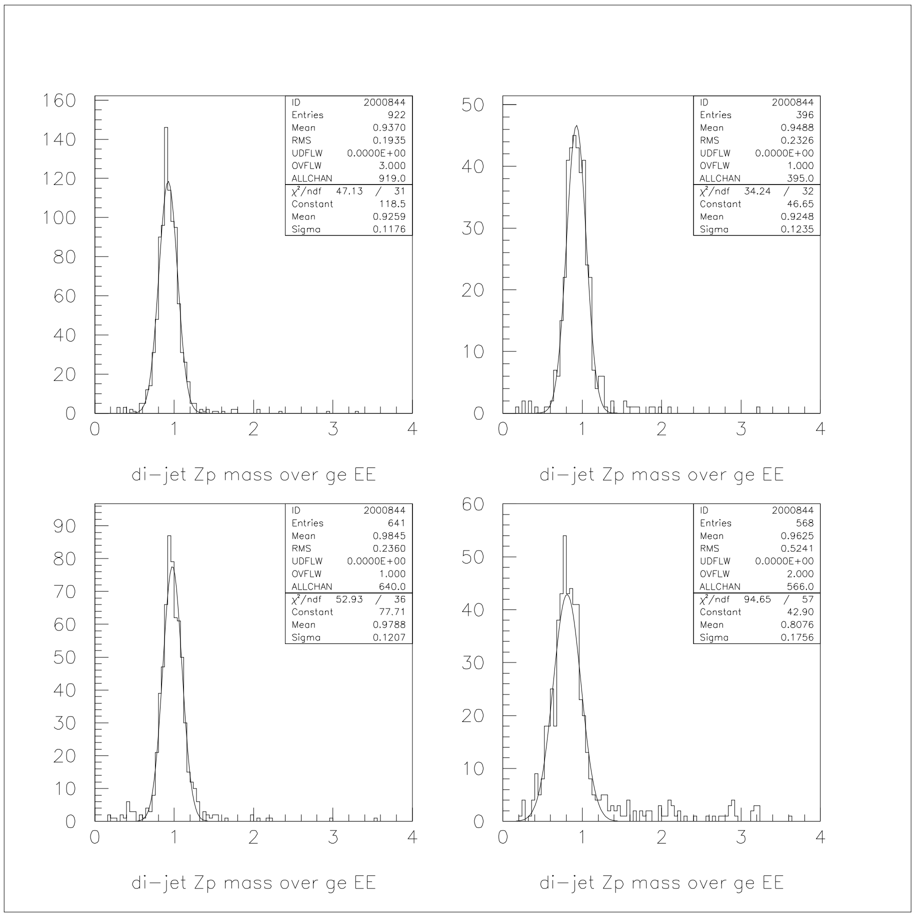

Figure 4: Dijet mass resolution, at least one jet is in the Endcap region: (a) full detector, (b) full detector, no Δ-ray production (c)without the Endcap Ecal (d) full detector with I/F radiation

Fig. 4 show the zp dijet mass distribution if we required that there is at least one of the two jets from the Zp is located in the η region of 1.8 to 2.3, namely in the Endcap Ecal region. Conclusion is the same with Fig.3. It emphasizes that without the Endcap Ecal did not change the mass resolution significantly.

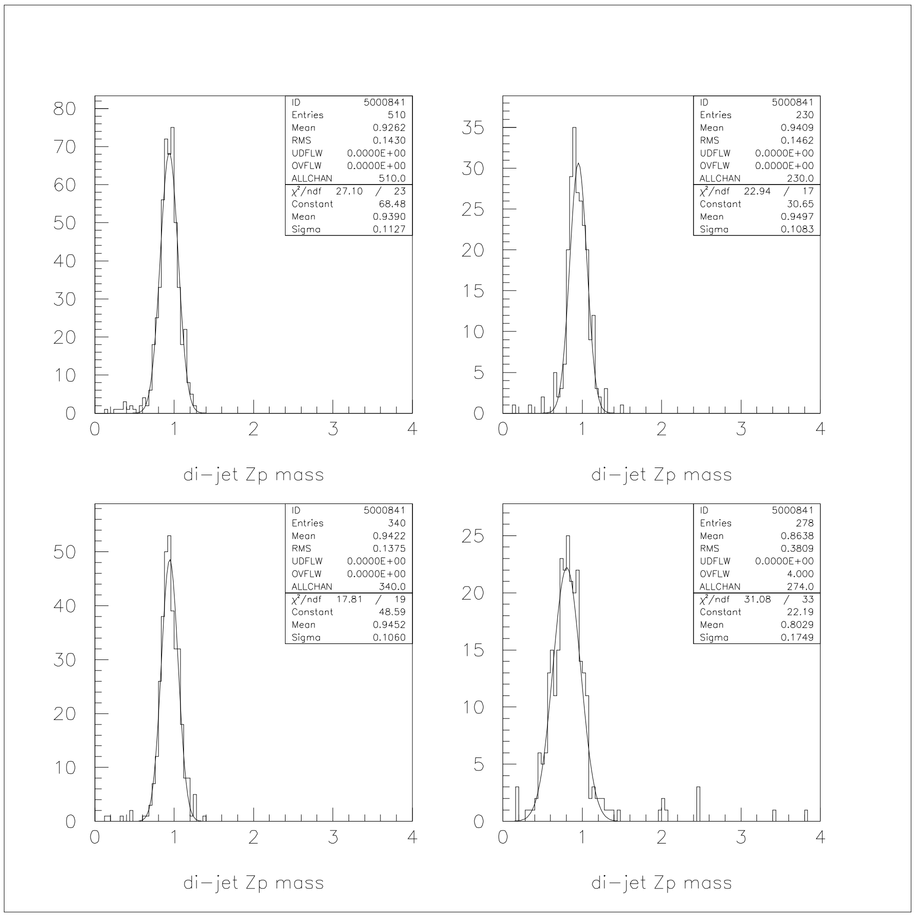

Figure 5: Dijet mass resolution,both jets are in the barrel part: (a) full detector, (b) full detector,no Δ-ray production (c)without the Endcap Ecal (d) full detector with I/F radiation

Fig. 5 show the the zp dijet mass distribution if we required that the both of jets are located in the barrel part, namely η is less than 1.(consider the cone size is already 0.5). The mass resolution is slightly better than case with all η region, and almost no events are in the high side tail. This is also what we have expected since we have much better HCAL in the barrel part.

5 Results from ORCA

The purpose to run ORCA to do the analysis is to verify the results from the cmsim, also we want to test the ORCA system in PC, which is NINOMIYA PC with Linux system at Fermilab. Due to space limitation, we don't have same statistics with the results from cmsim, also the case with I/F radiation was not proceeded. However, it is enough to conclude that the ORCA works well in PC at Fermilab, and get consistent results with the results from cmsim directly. Our experience run ORCA in PC also indicate that the ORCA system needs to make improvements to be more user friendly package.

Fig. 6 show the results for case with full detector. The resolution is 14.9 % vs 14.2 % from the cmsim120, the tail is 2.3 % vs 1.7 %. Jet multiplicity is very similar to the cmsim results.

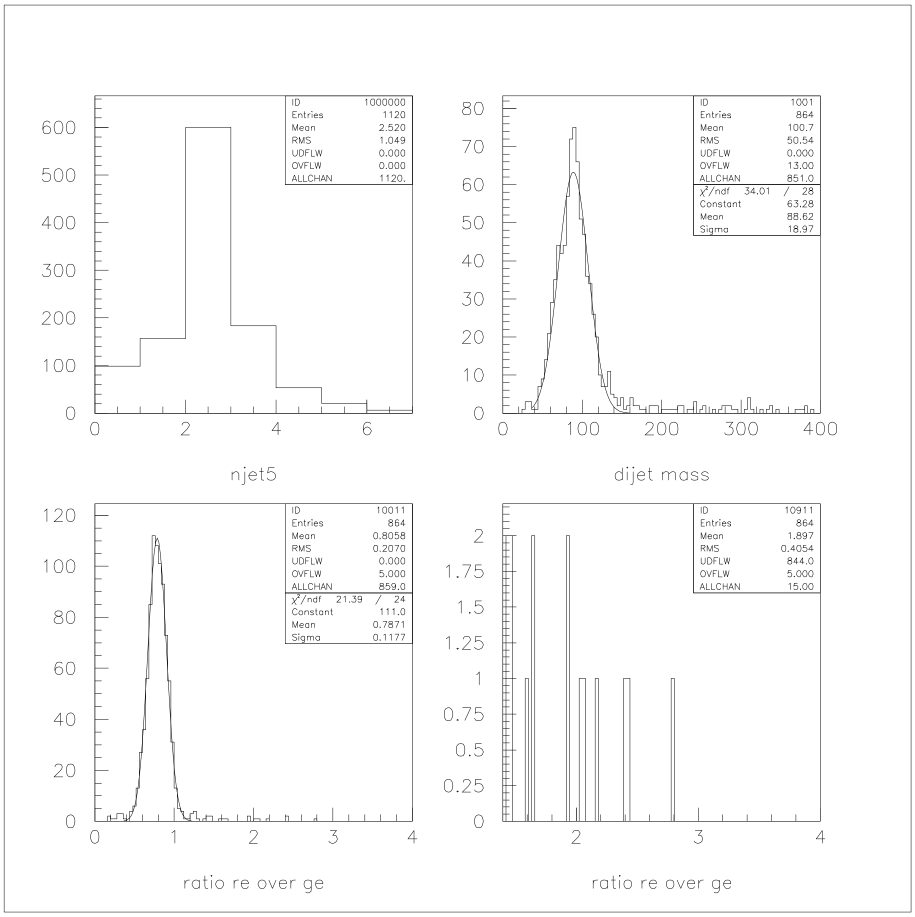

Figure 6: Results from ORCA for full detector: (a) jet multiplicity, (b) dijet mass (c) dijet mass resolution (d) the resolution tail.

Fig. 7 show the results for case without the Endcap Ecal. The resolution is 13.6 % vs 13.8 % from the cmsim120, the tail is 1.1 % vs 2.0 %. Jet multiplicity is very similar to the cmsim results.

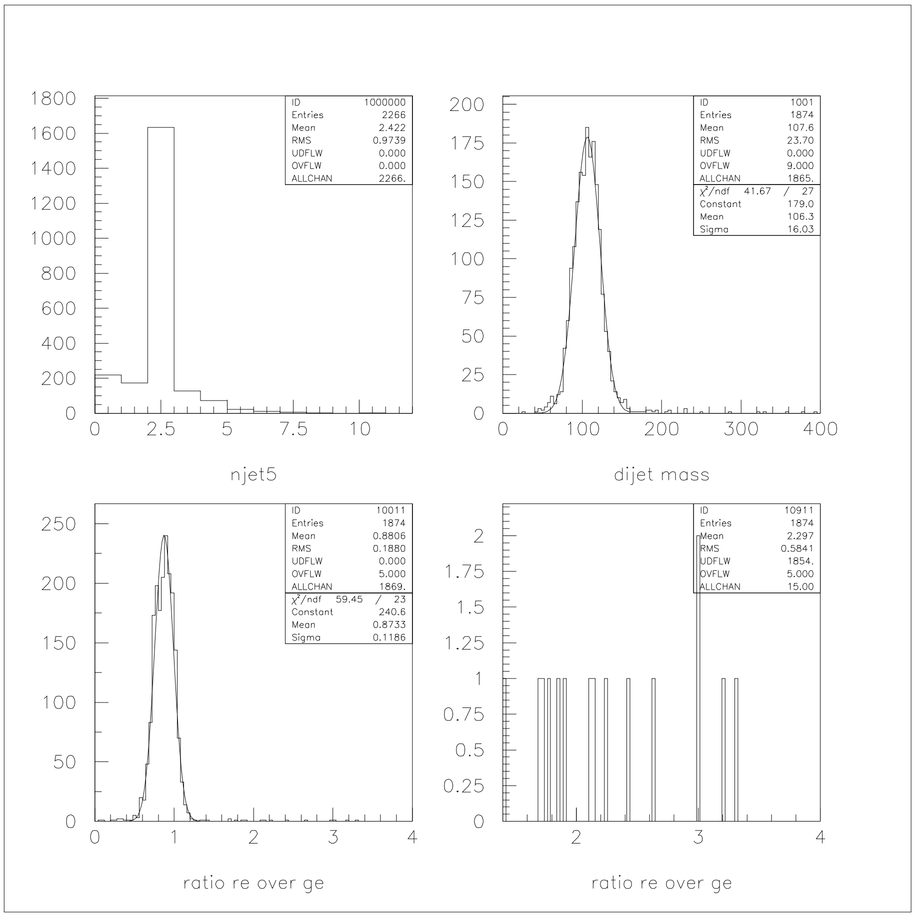

Figure 7: Results from ORCA for case without the Endcap Ecal:
(a) jet multiplicity,(b)dijet mass(c) dijet mass resolution (d) the resolution tail.

Fig. 8 show the results for case without Δ-ray production. The resolution is 12.6 % vs 14.5 % from the cmsim120, the tail is 1.7 % vs 2.5 %. Jet multiplicity is very similar to the cmsim results.

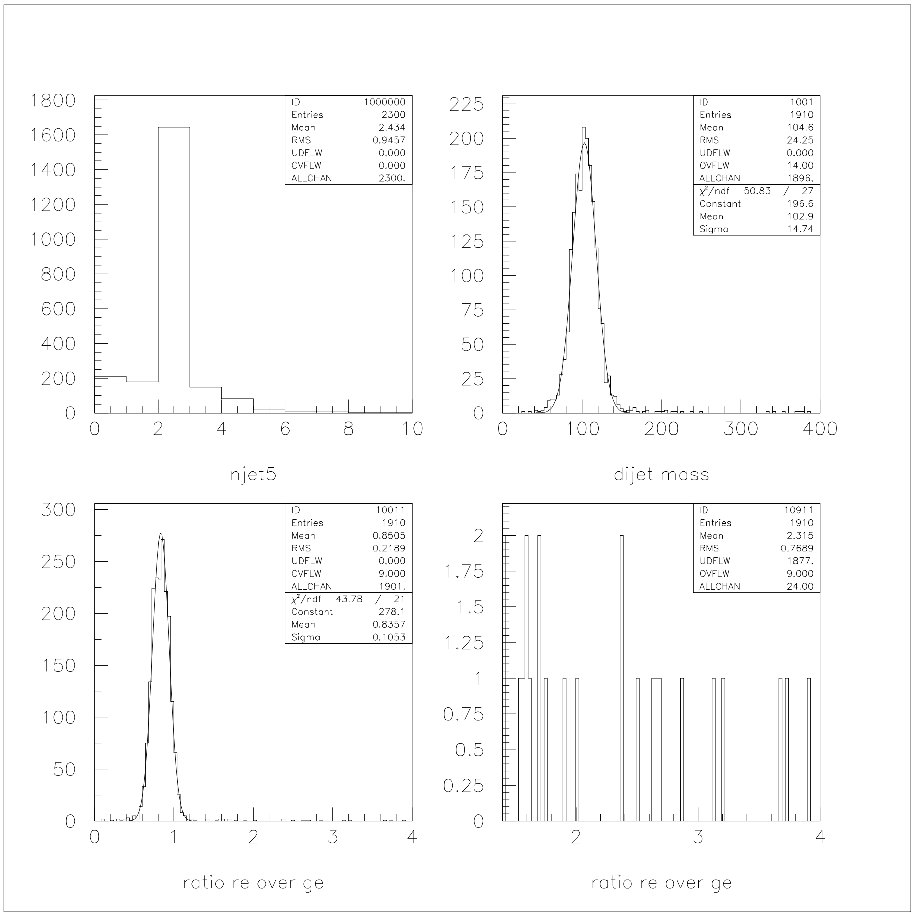

Figure 8: Results from ORCA for case no Δ-ray production :
(a) jet multiplicity,(b)dijet mass(c) dijet mass resolution (d) the resolution tail.

Consider the statistics differences and error, we did not see significant differences between the cmsim120 and the ORCA, as it should be.

6 Conclusion

Zp dijet mass resolution will not be degraded if without the Endcap Ecal for the first stage run at the CMS experiment. The ORCA program runs well in the PC at Fermilab.

Acknowledgments

We would like to thank Hans Wenzel, for his great help to install ORCA software in PCs at Fermilab, and the training to help us to run the program.

References

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